How the Eyes work in Viewing S3D

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A research consortium supporting
"Quality Sustainable Vision"

Goal:

- How to set the camera settings
- Primary camera settings
  - Length of lens (e.g. 35, 50, 135 mm etc.
  - Inter-axial (IA) distance
  - Convergence angle
  - Disparity budget
- A key underlying parameter is the disparity budget

Disparity Budget

More audience symptoms

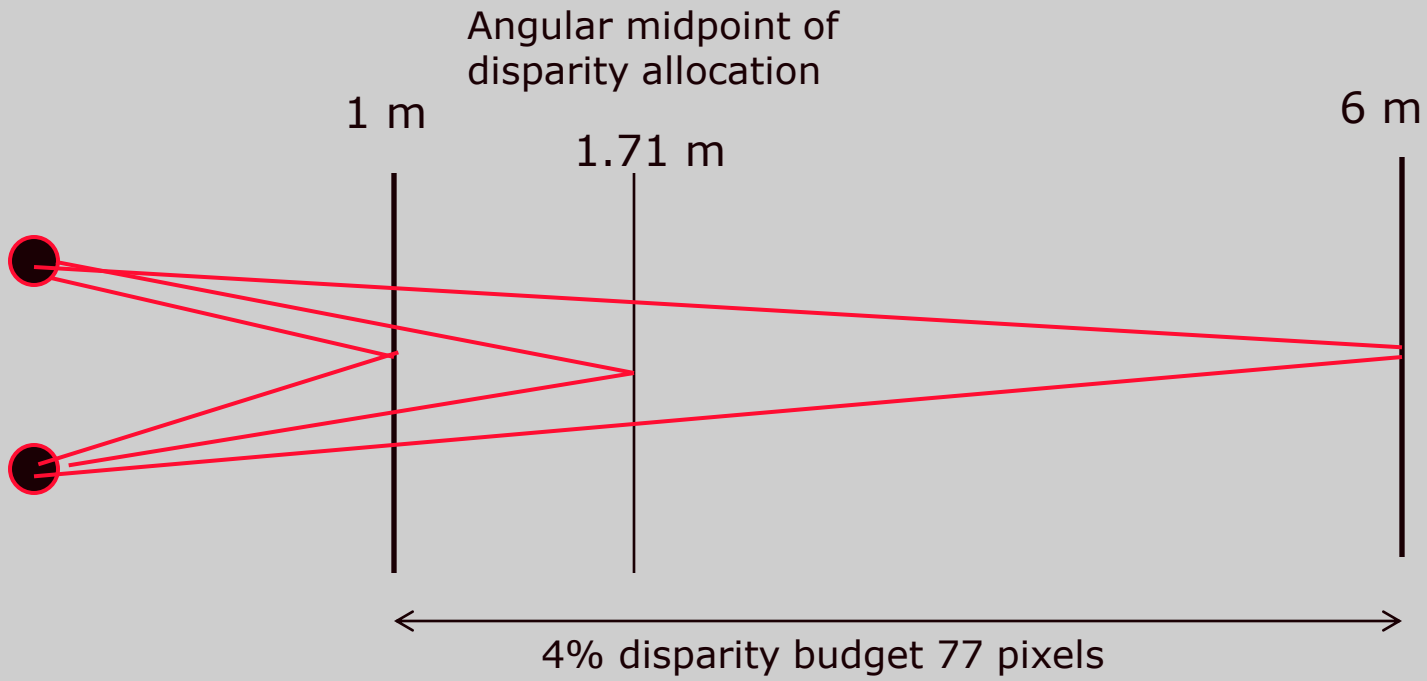
Best immersion

Low

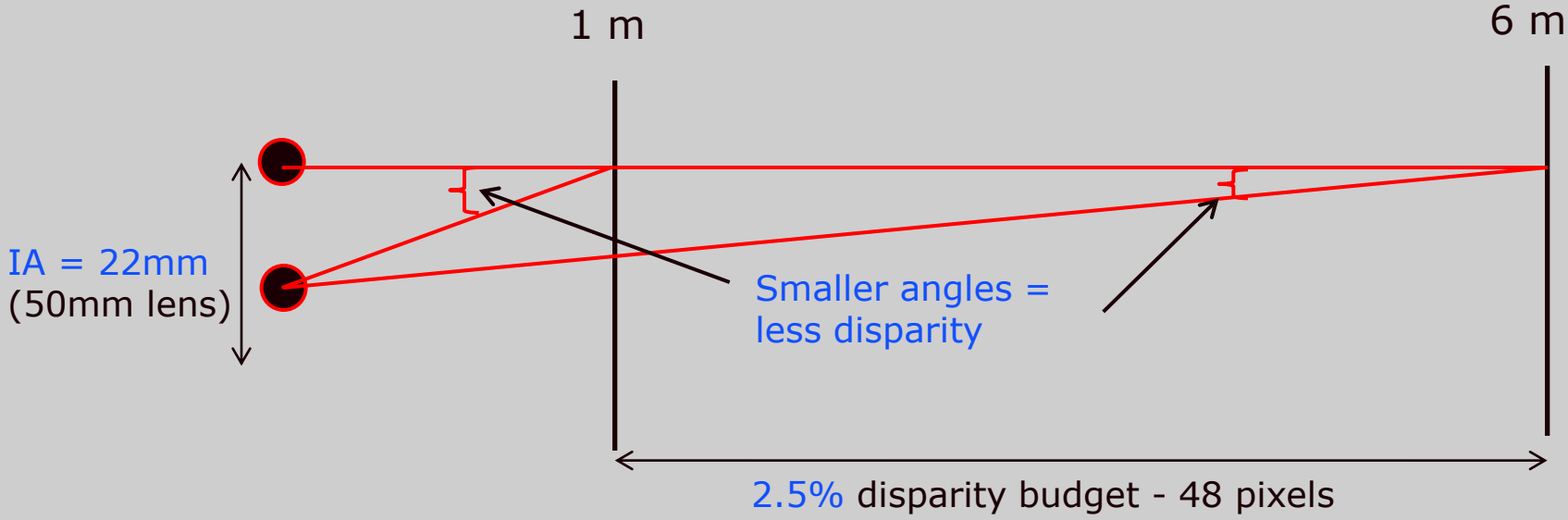
High

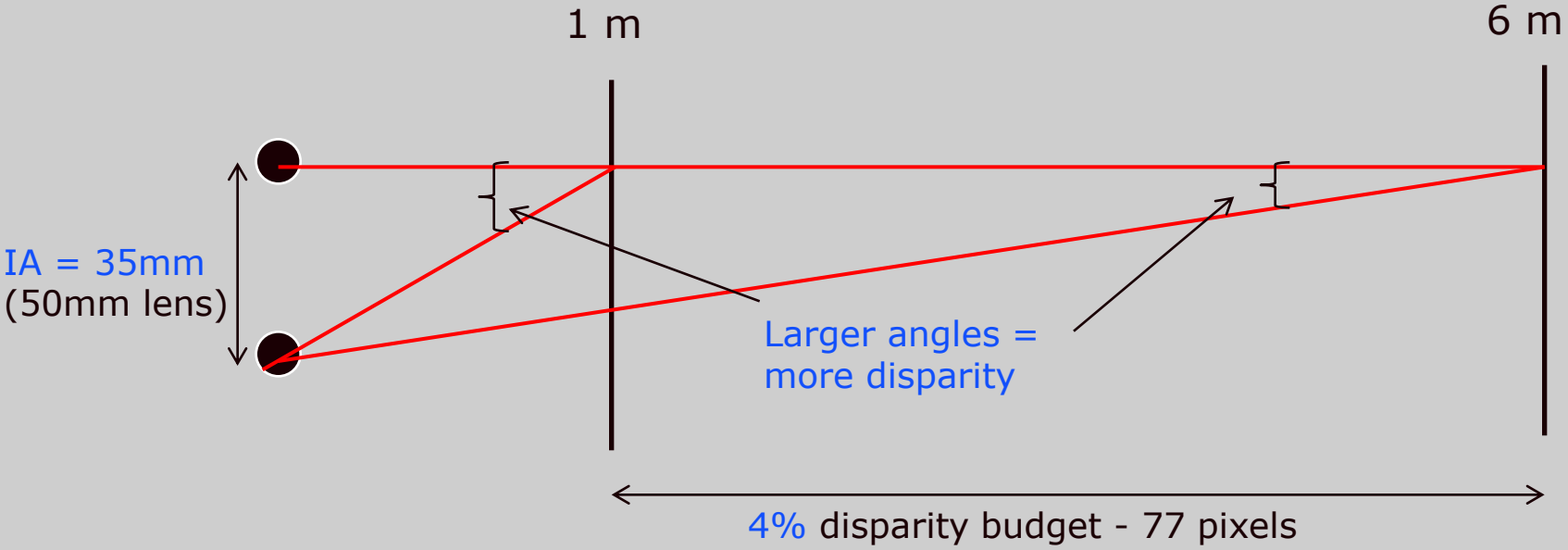
Current filming operation:

- **Identify the far and near distances in the scene**
- **The disparity budget will be allocated to that range**
  - **For example, 1m to 6m (3’ to 20’)**



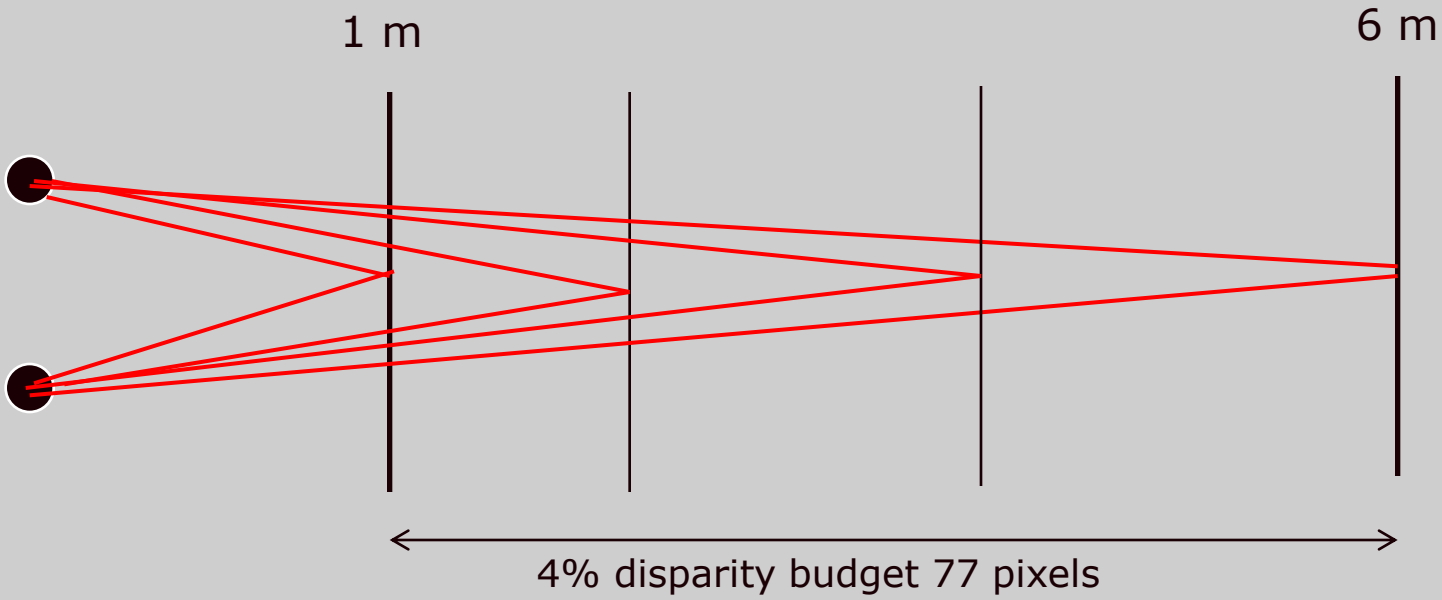
IA controls disparity budget





Convergence angle (CA) of cameras

- **Controls the zero disparity distance within the selected viewing distance range**



Convergence Angle (CA)

- Determines depth at which no vergence is required
  - i.e. the right and left eye images lay on top of one another
- Likely want to avoid divergence
  - Could set CA at far end of depth range
- Change CA during filming to look at intended target
  - Minimize audience vergence changes
  - James Cameron technique

Setting the cameras for S3D

- Early decisions that become a constant for remainder of the scene.
  - Focal length of the lens
    - Wide angle, normal, telephoto
  - The far and near scene depths to capture
- Next
  - Determine the disparity budget %
    - This establishes the IA setting
  - Determine the CA

2 Primary Camera Settings

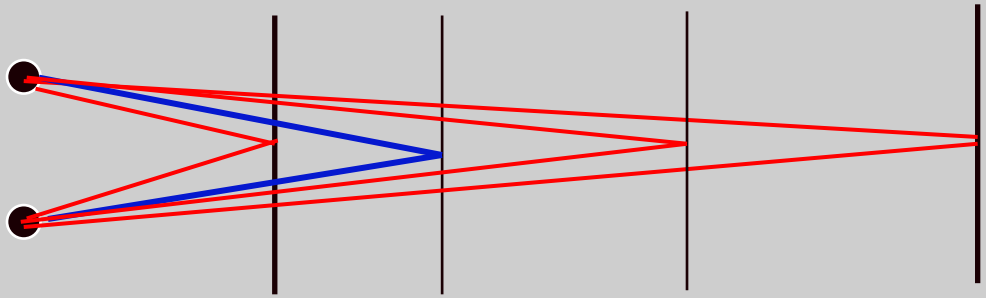
- **Inter-Axial (IA) distance**
  - **Directly determined by chosen disparity budget**
  - **Affects perceived depth: audience discomfort ratio**
- **Convergence**
  - **Affects the ocular convergence:divergence requirements of the scene**
  - **Affects audience discomfort**

Study design

- Film a scene multiple times
  - 4 IA settings (Disparity budgets)
    - With CA fixed
  - 4 CA settings
    - With IA fixed
- Test human preference with pair-wise comparisons of the 4 conditions
  - 6 unique pairs all shown
  - Immersion and comfort preference statistically determined
- Total test time, assuming 1 minute video, each pair takes 4 minutes with inter-trial time
  - 24 minutes for IA trials
  - 24 minutes for CA trials
  - Total = 48 minutes

Another test variable

- How the visual system interacts with the scene
  - Steady vergence: Ocular vergence remains near central depth in scene
    - E.g. watching 2 actors in conversation
    - Still want to appreciate depth, but don't change ocular vergence much
  - Dynamic vergence: Ocular vergence changes considerably during the scene
    - E.g. action scene, sports, barroom brawl



For each scenario

- IA series is tested
- CA series is tested
- Total testing time = 96 minutes

Hypotheses

- IA (Disparity budget)
  - Positively related to quality of perceived depth
  - Inversely related to comfort
  - Larger IA preferred for Steady Vergence
    - Provides greater depth appreciation, vergence changes not needed
  - Smaller IA preferred for Dynamic Vergence
    - Vergence changes required and hence need minimized
- CA
  - Steady vergence: CA preferred at plane of targets
    - Zero vergence requirement
  - Dynamic vergence: CA preferred at further distance
    - Avoids divergence requirements

Scene Requirements

- 1 minute in length
- Rich in depth
- Steady vergence and Dynamic Vergence
  - One scene?...or 2?
  - Same depth range for both
- Depth range: 1m to 6m
- Disparity budgets: 2, 3, 4, 5%
  - Set by altering the IA
- Convergence angles: 50, 65, 80, and 100% of range.

Messages

- To stereographers
  - Advice on setting IA and CA
  - Effect of scene content (manner in which eyes are used) on settings
- To public
  - We are providing guidelines for more effective and comfortable viewing of S3D

Future

- This study is effectively a proof-of-principle.
- Further studies can refine these initial findings
  - Effects of changing CA to the intended target
  - Object movement in depth vs vergence changes
    - i.e. possible separate effects of vergence discomfort and visually-induced motion
  - Finer testing of CA and AI settings

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